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August 23, 2019

VIA EMAIL: watersupply@dep.nj.gov

Ms. Linda Ofori
Bureau Chief
Mail Code 401-04Q
NJDEP – Division of Water Supply
Bureau of Water Systems Engineering
P.O. Box 420
Trenton, NJ 08625-0420

Re: Bordentown City Water Department
PWS-ID No. 0303001
Corrosion Control Study Plan
NJDEP Letter No. LCR180001

Dear Ms. Ofori:

In response to the New Jersey Department of Environmental Protection (NJDEP) Letter No. LCR 180001 dated July 1, 2019 (which was not received by the City until August 2, 2019), Remington & Vernick Engineers (RVE) is submitting a proposed Plan for a Corrosion Control Treatment (CCT) Demonstration Study for the Bordentown City Water Department (BCWD). The Plan was prepared in accordance with the United States Environmental Protection Agency (USEPA) document entitled "Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems", updated March 2016.

Background / System Description

The BCWD operates a Public Community Water System (PCWS) that serves approximately 16,000 people in both Bordentown City and Bordentown Township, Burlington County, and supplies bulk water to the Borough of Fieldsboro. The system contains approximately 80 miles of water mains with approximately 4,860 residential connections and 320 commercial/Industrial connections. The system supplies water from a series of four wells drawing from the Potomac-Raritan-Magothy Formation. Table 1 below provides details on the wells:

TABLE 1
Bordentown City WD Wells

Well #	Date Drilled	Depth (ft)	Capacity (gpm)
1	1964	126	800
2R	2016	198	1,000
3	1965	140	1,100
5R	2015	200	1,000
Total			**3,900**

In the second half of 2017, the BCWD received a Notice of Violation for lead action level exceedance (ALE) of 15 ug/l at the 90th percentile of samples. While the BCWD took actions to identify and assess optimal corrosion control treatment (OCCT) options, the system again exceeded the LAL in both standard monitoring periods of 2018. In late 2018, the BCWD recommended and received approval from NJDEP for the addition of an ortho/polyphosphate blend at their Water Treatment Plant; inhibitor feed began in November 2018.

The system again experienced an ALE exceedance in the first half of 2019. While it is possible that the distribution system piping may not have yet been fully passivated by the inhibitor (it normally takes a system approximately 6-12 months to come to a full equilibrium with the new treatment), both the NJDEP and the BCWD agree that alternative treatment options should be considered. A letter was issued by the NJDEP on July 1, 2019 required the conduct of a new Corrosion Control Demonstration Study, to be completed by August 15, 2020.

Table 2 presents a summary of lead compliance sampling from 2017 to 2019.

Water Quality / Previous and Current Treatment

The BCWD owns and operates a single water treatment facility, located off of US Route 206 in Hamilton Township, Mercer County (just across the Crosswicks Creek border with Bordentown). The facility is rated for a capacity of 2,800 gpm. Treatment at the facility currently includes cartridge filtration (for turbidity/particulates), iron sequestering (Klenphos 300), radium removal (via Z-88 ion exchange media from WRT), air stripping, pH adjustment, corrosion inhibitor (Klenphos 400) and gas chlorination. Three (3) high service pumps are used to pump the treated water into the distribution system.

REMINGTON & VERNICK ENGINEERS

BORDENTOWN CITY WATER DEPT.

CORROSION CONTROL STUDY PLAN

TABLE 2

Lead Sampling Results 2017-2019

Sample Point	Location	Tier	Sample Category	2017.2 (ug/L)	2018.1 (ug/L)	2018.2 (ug/L)	2019.1 (ug/L)
PBCU1	231 Crosswicks Road	1	ii			<1	
PBCU2	501 Oliver Street	1	ii		6.5		
PBCU3	505 Oliver Street	1	ii	27	101	49	62
PBCU4	509 Oliver Street	1	ii	21	2.5	2	<1
PBCU5	515 Oliver Street	1	ii	20	105	14	
PBCU6	1 Park Street	1	ii			<1	
PBCU7	2 Park Street	1	ii	<1		<1	<1
PBCU8	3 Park Street	1	ii			<1	6
PBCU9	4 Park Street	1	ii	1.5	<1	<1	<1
PBCU10	5 Park St Hamlet	1	ii			<1	3
PBCU11	6 Park St Hamlet	1	ii	<1	0.12	<1	<1
PBCU12	7 Park St Hamlet	1	ii	<1	0.95		
PBCU13	8 Park St Hamlet	1	ii	<1	0.094	<1	<1
PBCU14	107 Spring Street	1	ii	140	293	58	
PBCU15	109 Spring Street	1	ii				10
PBCU16	24 W Constitution Dr	1	ii	22	9	12	<1
PBCU17	28 W Constitution Dr	1	ii		0.71	<1	<1
PBCU18	30 W Constitution Dr	1	ii	<1		<1	
PBCU19	32 W Constitution Dr	1	ii	<1	<1	<1	<1
PBCU20	34 W Constitution Dr	1	ii	<1	2.4		
PBCU21	36 W Constitution Dr	1	ii	<1	<1		
PBCU22	38 W Constitution Dr	1	ii	610	3.1	<1	1
PBCU23	40 W Constitution Dr	1	ii	8.9	9.5	<1	<1
PBCU24	42 W Constitution Dr	1	ii	<1	<1	<1	<1
PBCU25	44 W Constitution Dr	1	ii	<1	<1		
PBCU26	46 W Constitution Dr	1	ii	<1	1.1	<1	
PBCU27	48 W Constitution Dr	1	ii	<1		<1	<1
PBCU28	50 W Constitution Dr	1	ii	<1		27	<1
PBCU29	500 Willow Street	1	ii	25		<1	<1
PBCU30	504 Willow Street	1	ii	11	1.4	<1	
PBCU31	508 Willow Street	1	ii	<1		<1	11
PBCU32	512 Willow Street	1	ii	<1		<1	<1
PBCU33	5 Bank Street	3	vii	<1	3.2	49	4
PBCU34	309 Borden Street	3	vii	<1	<1	<1	<1
PBCU35	2 Cemetary Lane	3	vii	---	63.6		
PBCU36	19 Charles Bossert Dr	3	vii	43	9.1	32	<1
PBCU37	40 Chestnut Street	3	vii			15	110
PBCU38	20 Crosswicks St	3	vii	360	<1	<1	
PBCU39	211 Crosswicks St	3	vii	37	10.5	4	12
PBCU40	213 Crosswicks St	3	vii	24	23.4	5	25
PBCU41	120 E. Burlington St	3	vii	<1	<1	<1	<1
PBCU42	70 E. Park Street	3	vii	<1		<1	
PBCU43	30 E. Union Street	3	vii	32			
PBCU44	46 E. Union Street	3	vii	13	3.9	<1	<1

BORDENTOWN WATER DEPARTMENT
LEAD SAMPLING STUDY

Sample Point	Location	Tier	Sample Category	2017.2 (ug/L)	2018.1 (ug/L)	2018.2 (ug/L)	2019.1 (ug/L)
PBCU45	907 East Drive	3	vii		0.59	1	
PBCU46	150 Farnsworth Ave	3	vii			<1	
PBCU47	203 Farnsworth Ave	3	vii	1.2		<1	
PBCU48	374 Farnsworth Ave	3	vii			284	
PBCU49	504 Farnsworth Ave	3	vii		0.84	<1	<1
PBCU50	506 Farnsworth Ave	3	vii	<1	2.8	<1	<1
PBCU51	512 Farnsworth Ave	3	vii				
PBCU52	10 Henry Marshall Dr	3	vii	2.8	0.06	<1	<1
PBCU53	7 Homestead Ave	3	vii	<1	47.1	28	47
PBCU54	30 Landon Drive	3	vii	1.7	8.4	<1	15
PBCU55	24 Lexington Road	3	vii	<1		<1	1
PBCU56	141 Lucas Drive	3	vii				
PBCU57	4 Maple Avenue	3	vii	6.6	1.8		
PBCU58	22 Mary Street	3	vii	<1	0.64	<1	4
PBCU59	84 Mary Street	3	vii	<1	1.8	<1	<1
PBCU60	415 Oliver Street	3	vii		0.41		116
PBCU61	4 Lexington Road	3	vii			9	<1
PBCU62	63 Park Street	3	vii	27			
PBCU63	76 Park Street	3	vii	2.6		4	1040
PBCU64	98 Park Street	3	vii	3.8	0.51	<1	<1
PBCU65	336 Prince Street	3	vii	<1	0.35	<1	<1
PBCU66	56 Second Street	3	vii	<1	0.67	<1	<1
PBCU67	135 Second Street	3	vii				
PBCU68	136 Second Street	3	vii				<1
PBCU69	138 Second Street	3	vii	<1	<1	<1	<1
PBCU70	223 Spring Street	3	vii	1.3	4	4	4
PBCU71	231 Spring Street	3	vii	130	3.3		1
PBCU72	234 Spring Street	3	vii	<1	33.6	<1	<1
PBCU73	11 Sweetbriar Lane	3	vii	1.5	1.7	6	18
PBCU74	18 Thorntown Lane	3	vii	<1		3	<1
PBCU75	46 Thorntown Lane	3	vii	7.6	23.2	9	50
PBCU76	14 Union Street	3	vii	<1	0.32		
PBCU77	5 Van Drive	3	vii	2.6		1	1
PBCU78	21 Van Drive	3	vii	3.9	12.6	0	125
PBCU79	23 Van Drive	3	vii	2.4	0.37	20	<1
PBCU80	34 Van Drive	3	vii	2.4	0.96	4	105
PBCU81	43 Vine Way	3	vii	<1	1.9	<1	<1
PBCU82	53 Vine Way	3	vii	19		9	3
PBCU83	150 W. Burlington St	3	vii		8	94	
PBCU84	16 W. Constitution Dr	3	vii	3	15.4	<1	<1
PBCU85	4 W. Union Street	3	vii	1.5	0.12		
PBCU86	7 Walnut Street	3	vii	14	51.4	<1	
PBCU87	307 Ward Avenue	3	vii	6.4	8.6	1	
PBCU88	19 Willow Road	3	vii	1.8		14	<1
PBCU89	27 Willow Road	3	vii			1	2
PBCU90	14 Yorktown Road	3	vii	4.8	50.4	<1	<1
PBCU91	348 Willow St	3	vii				
	90th Percentile Value			**30**	**43**	**28**	**50**

Recent treatment changes at the facility include:

1. The original greensand filter media was replaced in 2016 by the Z-88 media following the discovery of radium levels in excess of the Safe Drinking Water Act Maximum Contaminant Level (MCL).
2. A sequestering agent (Klenphos 300) was added prior to the WRT units to prevent oxidation of iron and manganese from fouling the media.
3. A blended phosphate corrosion inhibitor (Klenphos 400) was added post-stripper starting in 2018 as a result of previous ALE violations.
4. An automated pH control system was added to the existing lime feed in 2018 to better manage the finished water pH in the optimal range for the corrosion inhibitor.

Based upon sampling completed in June 2019, Table 3 below presents a current profile of the raw and treated water quality through the WTP:

TABLE 3
Raw and Treated Water Quality

Parameter		Raw	Post-Filter, Pre-Stripper	Post-Stripper, Post-Lime	POE
pH		4.6-4.9	4.71	7.38	7.7-8.0
Total Alkalinity *	mg/L	1-12	0.30	13.0	15-20
Total Hardness *	mg/L	3-13	3.6	4.9	7-30
Temperature	°C	12	13	16	18-20
Total Dissolved Solids	mg/L	40-56	39.0	50.0	54-76
Chloride	mg/L	3.1	3.0	3.1	3.1
Sulfate	mg/L	12.0	0.0	0.0	0.0
Iron as Fe (Total)	mg/L	ND-0.05	0.0	0.02	0.02
Manganese as Mn	mg/L	0.02-0.03	0.02	0.01	0.0
Orthophosphate as PO_4	mg/L	0.18	0.20	1.10	1.34
Polyphosphate as PO_4	mg/L	NA	0.12	0.64	1.45
Total phosphate as PO_4	mg/L	NA	0.32	1.74	2.79
Zinc	mg/L	0.12	1.25		0.35

(Note on Chloride – Sulfate Mass Ratio)
As can be seen in the profile above, the WRT radium removal units also remove sulfate from the BCWD's water, increasing the chloride – sulfate mass ratio from approximately 0.25 in the raw water to essentially infinite in the finished water. A high CMSR is suspected of exacerbating the leaching of lead from piping; however, after consultation with corrosion experts, we feel that this impact is not occurring in the BCWD system, as the absolute chloride level (3 mg/l) is not considered high enough to act as an accelerant at the corrosion sites.

Desktop Evaluation of Corrosion Control Alternatives

The desktop evaluation was conducted in accordance with the USEPA's "Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems" manual. The evaluation began with an analysis of the POE water quality and calculation of the Dissolved Inorganic Carbon (DIC) was calculated from the table within the manual, part of which is included as Table 4 below:

TABLE 4
Dissolved Inorganic Carbon (DIC) Table

Alkalinity	pH											
	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6
0	0											
2	1	1	1	1	1	1	0	0	0	0	0	0
4	2	1	1	1	1	1	1	1	1	1	1	1
6	3	2	2	2	2	2	2	1	1	1	1	1
8	4	3	3	2	2	2	2	2	2	2	2	2
10	4	4	3	3	3	3	3	2	2	2	2	2
12	5	4	4	3	3	3	3	3	3	3	3	3
14	6	5	4	4	4	4	4	3	3	3	3	3
16	7	6	5	5	4	4	4	4	4	4	4	4
18	8	7	6	5	5	5	5	4	4	4	4	4
20	9	7	6	6	5	5	5	5	5	5	5	5
22	10	8	7	6	6	6	6	5	5	5	5	5
24	11	9	8	7	7	6	6	6	6	6	6	6

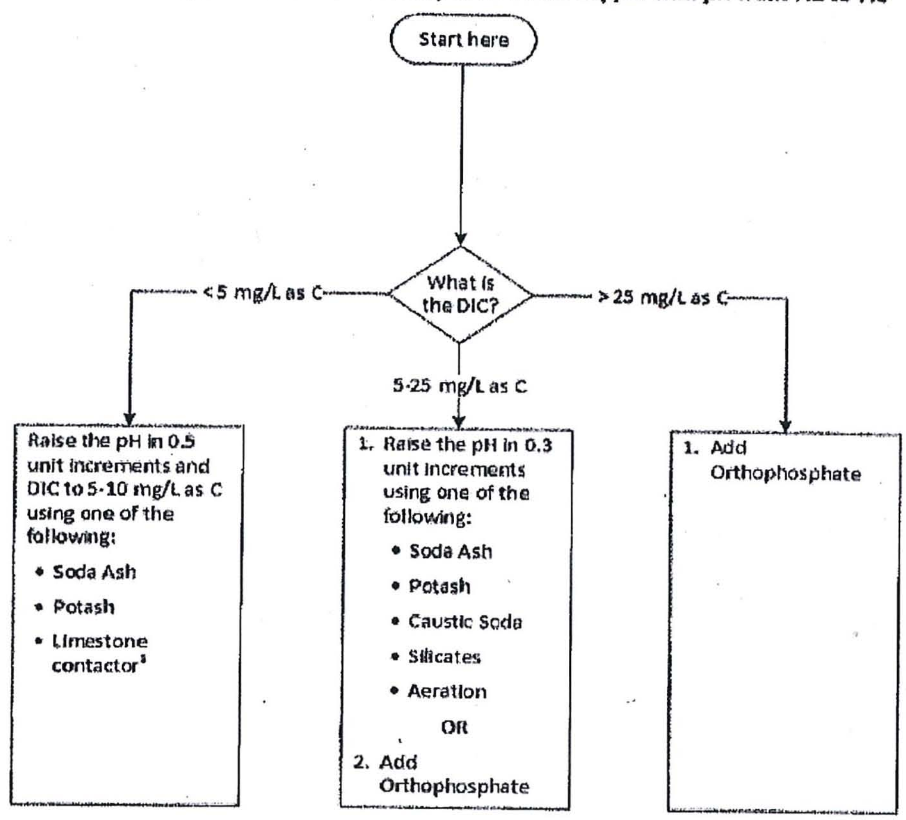
Utilizing a pH of 7.8 and an alkalinity of 20 mg/l (as CaCO3), DIC was determined to be 5 mg/l.

Exhibit 3.3 of the manual (reprinted below as Table 5) was then used to determine the proper flowchart to follow in determining treatment alternatives. Because iron and manganese are low (and treated with a sequesterant to prevent oxidation), the selection was made as if iron and manganese were NOT present in the water. Based upon the water quality data, it was determined that Flowchart 1b was the appropriate guidance to utilize. Flowchart 1b is reprinted below for reference.

TABLE 5
Identifying the Appropriate Flowchart for Preliminary CCT Selection

Is iron or manganese present in finished water?	What is the contaminant to be addressed:	What is the finished water pH?	Use this Flowchart
No	Lead only, or Lead and Copper	< 7.2	1a
		7.2 – 7.8	1b
		>7.8 – 9.5	1c
		> 9.5	1d
	Copper only	< 7.2	2a
		7.2 – 7.8	2b
		>7.8	2c
Yes	Lead and/or copper	< 7.2	3a
		>7.2	3b

Flowchart 1b: Selecting Treatment for Lead only or Lead and Copper with pH from 7.2 to 7.8



KEY:
AL = Action Level
Caustic soda = sodium hydroxide (NaOH)
DIC = Dissolved Inorganic Carbon
mg/L as C = milligrams per liter as carbon
Potash = potassium carbonate (K_2CO_3)
Soda ash = sodium carbonate (Na_2CO_3)

Footnotes:

1. Carbon dioxide feed before the limestone contactor may be necessary.

According the flowchart, the following options should be considered for corrosion control:

1. Raise the pH adjust using one of the following:
    a. Soda Ash
    b. Potash
    c. Caustic Soda
    d. Silcates
    e. Aeration
2. Add orthophosphate

The following subsections review each of these treatments and any constraints upon their use.

pH Adjustment

As noted above, the BCWD already performs pH adjustment using both lime and packed tower aeration. The aeration is necessary for the removal of Volatile Organic Compounds (VOC's); however, it has the following secondary effects:

a. It reduces the amount of lime needed for pH adjustment; and
b. It removes CO2 from the raw water, reducing the DIC by an estimated 10-20 mg/l.

While this reduction in DIC is a negative influence on corrosion control (reducing the buffer capacity of the water), it is unavoidable due to the need to remove VOC's (the alternative for VOC removal is tearing down the stripper ad installing a GAC contactor, which would effectively increase the DIC in the finished water and improving corrosion control performance. This option would be prohibitively expensive when compared to current treatment, since it would include new contactor vessels (and a building expansion to house them), abandonment of the clearwell and high service pumps, and the replacement of existing well pumps with higher-head units (and associated electrical upgrades).

Overall, with current level of 7.8-8.0, the BCWD does not have much leeway in further adjusting pH. An increase of 0.3 – 0.5 units (as called for in the flowchart) brings the finished water very near the upper limit of 8.5 permitted by the SDWA. At these pH levels, the water quality can result in aesthetic complaints from customers and can increase scaling in hot water heaters and other home fixtures.

Potash and silicates are not common forms of pH treatment for public community water systems; they will not be discussed further herein, leaving caustic soda and soda ash as potential chemical feeds, either in place of or in addition to lime feed. Caustic soda (sodium hydroxide) is effective in raising the pH; however, it does not increase DIC, and is very difficult to maintain pH control in poorly buffered (i.e., low DIC) waters.

Soda ash (sodium carbonate) is a technically feasible method of pH adjustment and has the added benefit of increasing DIC and buffer capacity. However, soda ash is less effective in raising pH than lime, meaning more chemical would be required. In addition, unless the soda ash were to completely replace the lime feed, there is insufficient space in the water treatment facility to locate new fed pumps and storage. A building extension would be needed, increasing the cost even further and making the change less economically feasible.

For these reasons, pH/alkalinity/DIC adjustment is not considered a feasible corrosion control alternative for the BCWD.

Phosphate-based Corrosion Inhibitor

Phosphate-based corrosion inhibitors are chemicals that have orthophosphate in their formulation.17 Orthophosphate reacts with divalent lead and copper (i.e., Pb++ and Cu++) to form compounds that have a strong tendency to stay in solid form and not dissolve into water. The extent to which orthophosphate can control lead and copper release depends on the orthophosphate concentration, pH, DIC, and the characteristics of the existing corrosion scale (e.g., whether it contains other metals such as iron or aluminum).

The original OCCT recommendation for the BCWD was for a phosphate-based inhibitor (Klenphos 400, a blended ortho/polyphosphate mix); this recommendation was approved by the NJDEP in July 2018 and treatment initiated in November 2018. As noted previously, a change in corrosion control treatment may take 6-12 months for the distribution piping to reach a new equilibrium; therefore, it may be that the treatment had not yet achieved maximum effect at the time of the subsequent round of compliance sampling (April 2019). In support of this theory, RVE reviewed the results of free (non-compliance) lead sampling offered to all residents in the City and Township. This sampling (which follows the same protocols as compliance sampling) allows results to be tracked on a month-by-month basis. Table 6 below presents the results of the free sampling.

TABLE 6
Free Resident Lead Sample Results

Month	# of Samples Taken	# of Samples Exceeding LAL	% of Samples Exceeding LAL
January	20	6	30%
February	13	3	23%
March	20	2	10%
April	11	0	0%
May	18	3	16%
June	10	1	10%
July (thru 7/15)	7	0	0%

The results indicate a gradual improvement in corrosion control, with fewer exceedances as time goes on. While it is possible that continuance of the Klenphos 400 would further improve performance into the second half of 2019, the BCWD has met with several chemical vendors to see if there was an inhibitor that might improve performance. Based upon those meetings, RVE has recommended to the City that the blended phosphate be replaced with a straight zinc orthophosphate (ZOP) product. The ZOP will have some additional benefits to the system:

1. The increased zinc will help protect the many galvanized services within the distribution system; and
2. Because the ZOP contains some sulfate, it will restore some of the balance in the CSMR (see above). Based upon estimates from the vendor, approximately 0.6 mg/l of sulfate will be present in the finished water after the initial passivation period.

The ZOP is expected to significantly reduce the potential for lead corrosion. Included in this Plan is a water quality model spreadsheet (Water!Pro software) supporting this prediction, based upon actual raw water characteristics and proposed chemical addition.

A new application for Temporary Treatment Approval for the change in chemical will be submitted under separate cover, including detailed dosing and storage calculations.

Proposed Treatment and Monitoring of Performance

Given the fact that the BCWD is already adding a phosphate-based inhibitor under an approved OCCT study and Temporary Treatment Approval from the NJDEP; we proposed to conduct a full-system demonstration study with the zinc orthophosphate addition, in lieu of pipe loop, coupon or partial-system testing. Utilizing a full-system test will permit the accurate measurement of impacts on the distribution system and home plumbing and allow the system customers access to the benefits of the increased corrosion protection.

The selected ZOP product is known as SLI-5216, a 1:5 zinc:orthophosphate compound (see attached Material Safety Data Sheet). The chemical will be stored in two 300-gallon polyethylene drums and fed using the existing Klenphos 400 pumps. Dosing of the ZOP is proposed as follows:

1. Accelerated passivation period – 6 weeks @ 5.0 mg/L as Orthophosphate; 1.0 mg/L as Zinc; 16.0 mg/L as SLI-5216 (1.44 mg/l sulfate added; CSMR=2.08)

2. Acclimation/stabilization period – 20 weeks @ 3.0 mg/L as Orthophosphate; 0.6 mg/L as Zinc; 9.7 mg/L as SLI-5216 (0.87 mg/l sulfate added; CSMR=3.45)

3. Maintenance period (remainder of study period)– daily @ 2.0 mg/L as Orthophosphate; 0.4 mg/L as Zinc; 6.45 mg/L as SLI-5216 (0.58 mg/l sulfate added; CSMR=5.17)

WaterPro™

Treating Drinking Water

Step 1: Initial Water Characteristics

Save (S#)/Retrieve (R#) Data: S1 S2 S3 S4 S5 / R1 R2 R3 R4 R5

Enter source water characteristics.

Source Point:	Bordentown POE		
Date of Sample:	June 5, 2019		
Plant Flow Rate =	1.6	MGD	1,111 gpm
TDS =	76	mg/L	0.00190 mol/L, Ionic Strength
pH =	7.33	field pH is recommended	
Total Alkalinity =	20.0	mg/L as $CaCO_3$	0.40 meq/L
Calcium (Total) =	12.0	mg/L Ca^{2+}	29.97 mg/L as $CaCO_3$
Water Temperature =	13.0	°C (temp. at which pH was analyzed)	
Field Water Temperature =	13.0	°C (operating temperature at facility)	
Cl^- =	1.0	mg/L	1.4 mg/L as $CaCO_3$
SO_4^{2-} =	0.6	mg/L	0.6 mg/L as $CaCO_3$
Mg^{2+} =	0	mg/L	0.0 mg/L as $CaCO_3$

If alkalinity is unknown, then enter target DIC and click "Find Alk" button.

Target DIC	25.0	mg/L as C	208.3 mg/L as $CaCO_3$

Enter source water characteristics (optional)

UVA-254 =		1/cm, UV Absorption	%UVT: 100.0
DOC =		mg/L as C (Dissolved Organic Carbon)	
Raw Water Turbidity =		NTU	SUVA = -

Step 2: Initial Results (Before Chemical Addition)

Theoretical initial water characteristics, corrosion indices & metals after temperature correction.

pH =	7.33		118.8	uS/cm (Electrical Conductivity)
Acidity =	24.8	mg/L as $CaCO_3$	0.677	mg/L, Atmospheric equilibrium $CO_{2(aq)}$
Carbon Dioxide (CO_2) =	2.14	mg/L as $CO_{2(aq)}$	0.58	mg/L as C, dissolved inorganic carbon
DIC =	44.8	mg/L as $CaCO_3$	5.38	mg/L as C, dissolved inorganic carbon

Corrosion Indices (Calcite)		<Select Cystalline Form	Recommended
Aggressive Index (AI) =	10.1	Moderately aggressive conditions for asbestos cement piping	>12
Ryznar Index (RI) =	10.78	Tendency to dissolve CaCO3 (for steel piping)	6.5-7.0
Langelier Index, Calcite =	-1.73	Tendency to dissolve CaCO3 (for steel and cast iron piping)	>0
CCPP =	-6.47	mg/L as $CaCO_3$, Calcium Carbonate Precipitation Potential	4-10 mg/L
$B_{H2O} + B_{CO3}$ =	0.101	mM/pH, Buffer intensity from water and carbonate species	
Alk/(Cl^- + SO_4^{2-}) =	9.6	Larson's Ratio for steel and cast iron piping	> 5.0

Select water temp. for Pb & Cu and select copper solid(s) for calculations

◉ Field Temperature ○ Temperature @ 25C ☑ Cupric Hydroxide ☐ Malachite ☐ Tenorite ☑ Cupric Phosphate

Copper II at 25C =	0.342	mg/L as copper II at dissolution; Cupric Hydroxide, light blue/blue-green
Lead II at 25C =	0.322	mg/L as lead II at dissolution; Lead Carbonate (cerussite) CSMR: 1.67
pH_{25} =	7.24	pH of water if measured at 25°C

Pb & Cu Guidance — Click button for Guidance on Lead & Copper Treatment. Applies to data in Steps 2 or 6

Step 3: Chemical Interim Addition: Source Water Treatment

Source Water Treatment - Acid/Base Addition

Hydrochloric Acid (HCl)		mg/L	0.00 mg/L as $CaCO_3$
Sulfuric Acid (H_2SO_4)		mg/L	0.00 mg/L as $CaCO_3$
Carbon Dioxide (CO_2) ±		mg/L	0.00 mg/L as $CaCO_3$
$Ca(OH)_2$ (100% hydrated Lime)		mg/L	0.00 mg/L as $CaCO_3$
CaO (100% Quicklime)		mg/L	0.00 mg/L as $CaCO_3$
Soda Ash (Na_2CO_3)		mg/L	0.00 mg/L as $CaCO_3$
Caustic Soda (NaOH)		mg/L	0.00 mg/L as $CaCO_3$
Sodium Bicarbonate ($NaHCO_3$)		mg/L	0.00 mg/L as $CaCO_3$

Source Water Treatment - Coagulant Addition

Primary Coagulant	Secondary Coagulant
10% Acid Alum*14.3H2O	Aluminum Sulfate*14.3H2O

10% Acid Alum*14.3H2O		mg/L	0.00 mg/L as $CaCO_3$
Aluminum Sulfate*14.3H2O		mg/L	0.00 mg/L as $CaCO_3$

Step 4: Interim Results (After Chemical Addition)

Theoretical interim water characteristics

pH =	7.33	pH of water after chemical addition and before release of CO_2		
Total Alkalinity =	20.0	mg/L as $CaCO_3$	0.40	meq/L
Total Calcium =	12.0	mg/L Ca^{2+}	30.0	mg/L as $CaCO_3$
Acidity =	24.8	mg/L as $CaCO_3$	CCPP = -6.5	mg/L as $CaCO_3$
Carbon Dioxide (CO_2) =	2.14	mg/L as $CO_{2(aq)}$	0.58	mg/L as C

DOC Reduction after Coagulant/Acid/Base Addition

DOC =	-	mg/L as C	DOC Removed = -	mg/L as C
% of DOC Reduced =	-	after coagulant/acid/base treatment		
Nonsorbable DOC =	-	mg/L as C	1.4 mg TSS/NTU removed	
Aluminum Added =	0.000	mMol/L, 0.00 mg/L	$0.00	$ per million gallons
Ferric Added =	0.000	mMol/L, 0.00 mg/L	$0.00	$ per million gallons
Sludge Production =	0	lbs per MG	0.0 Kg/1000 m^3	0 lb/day 0 Kg/day

Step 5: Chemical Addition: Finished Water Treatment

Soda Ash (Na_2CO_3)		mg/L	0.00 mg/L as $CaCO_3$
Potash (K_2CO_3)		mg/L	0.00 mg/L as $CaCO_3$
Caustic Soda (NaOH)		mg/L	0.00 mg/L as $CaCO_3$
Potassium Hydroxide (KOH)		mg/L	0.00 mg/L as $CaCO_3$
Sodium Bicarbonate ($NaHCO_3$)		mg/L	0.00 mg/L as $CaCO_3$
$CaCO_3$ (Limestone)		mg/L	0.00 mg/L as $CaCO_3$
Calcium Chloride ($CaCl_2$)		mg/L	0.00 mg/L as Ca^{2+}
Orthophosphate as PO_4^{3-}	2.0	mg/L	0.65 mg/L as P^{3-}
Carbon Dioxide (CO_2) ±		mg/L	0.00 mg/L as $CaCO_3$

Disinfection & Fluoridation

Chlorine Gas (Cl_2)		mg/L as Cl_2	
Sodium Hypochlorite (NaOCl)		mg/L as Cl_2	
Calcium Hypochlorite ($Ca(OCl)_2$)		mg/L as Cl_2	
Hydrofluosilicic Acid (H_2SiF_6)		mg/L	0.00 mg/L as F^-
Sodium Silicofluoride (Na_2SiF_6)		mg/L	0.00 mg/L as F^-

Step 6: Final Results (After Corrosion Control Treatment) - Theoretical interim water characteristics, corrosion indices & metals (before $CaCO_3$ precipitation).

					Recommended
pH =	7.07	pH of water after chemical addition and before release of CO_2			6.8-8.0 or 8.5-9.3
					After precipitation
Total Alkalinity =	18.3	mg/L as $CaCO_3$	0.37	meq/L	pH = - unit
Total Calcium =	12.0	mg/L Ca^{2+}	30.0	mg/L as $CaCO_3$	Alk = - mg/L
Acidity =	26.5	mg/L as $CaCO_3$			CO_2 = - aq. mg/L
Carbon Dioxide (CO_2) =	3.59	mg/L as $CO_{2(aq)}$	0.98	mg/L as C	
DIC =	44.8	mg/L as $CaCO_3$	5.38	mg/L C, dissolved inorganic carbon	

Corrosion Indices			Recommended
Aggressive Index (AI) =	9.8	Extremely aggressive conditions for asbestos cement piping	>12
Ryznar Index (RI) =	11.12	Tendency to dissolve CaCO3 (for steel piping)	6.5-7.0
Langelier Index, Calcite =	-2.03	Tendency to dissolve CaCO3 (for steel and cast iron piping)	>0
CCPP =	-9.59	mg/L as $CaCO_3$, Calcium Carbonate Precipitation Potential	4-10 mg/L
$B_{H2O} + B_{CO3} + B_{PO4}$ =	0.166	mM/pH, Buffer intensity from water, carbonate, and PO_4 species	
Alk/(Cl^- + SO_4^{2-}) =	9.01	Larson's Ratio for steel and cast iron piping	> 5.0
Copper II at 25C =	0.13	mg/L as copper II at dissolution; Cupric Phosphate, blue	
Lead II at 25C =	0.017	mg/L as lead II at dissolution; Hydroxy-pyromorphite	CSMR: 1.67
pH_{25} =	6.98	pH of water if measured at 25°C	

Water/Pro ™

Corrosion Control Modeling Program

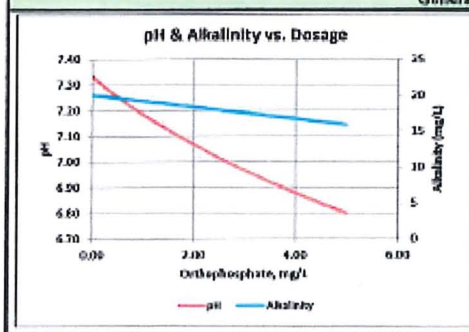
Step 1	Enter Characteristics of Water to be Treated			
System Name:	Example 5	Copy		
Source Point:	Bordentown POE			
Date of Sample:	June 5, 2019			
TDS =	76	mg/L		
pH =	7.33	field pH is recommended		
Total Alkalinity =	20.0	mg/L as $CaCO_3$		
Calcium (total) =	12.0	mg/L Ca^{2+}	29.97	mg/L as $CaCO_3$
Water Temperature =	13.0	°C (temp. at which pH was analyzed)		
Field Water Temperature =	13.0	°C (operating temperature at facility)		
Cl^- =	1.0	mg/L	1.4	mg/L as $CaCO_3$
SO_4^{2-} =	0.6	mg/L	0.6	mg/L as $CaCO_3$
Mg^{2+} =	0	mg/L	0.0	mg/L as $CaCO_3$

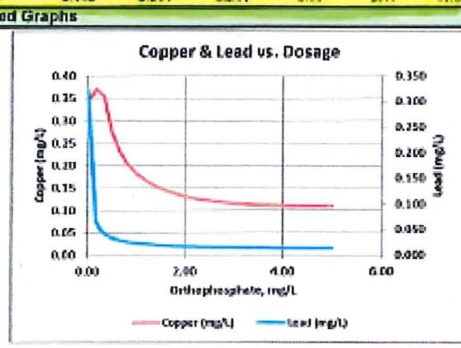
Step 2	Chemical Selection & Constraints	
Select Corrosion Control Chemical	Orthophosphate	
Enter Constraints:		
Upper limit dose to plot:	5.0	mg/L
Upper Bound pH:	9.0	
Step 3	**Enter Desired Dose if Added**	
Orthophosphate as PO_4^{3-}	0.0	mg/L
Step 4	Plot Data	Activate button "*Plot Data*" to plot any new data entered in Steps 1 to 3.

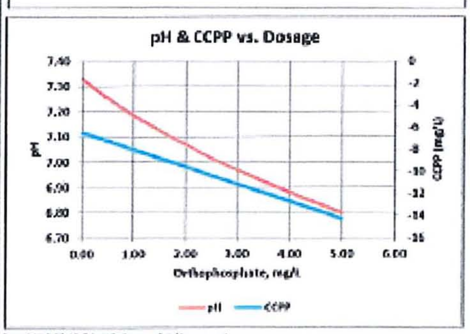
Plotting Points for Graphs

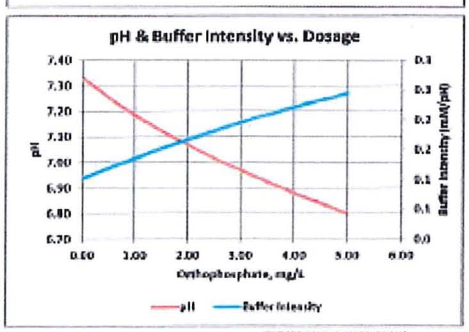
Dosage mg/L	with Ortho mg/L	pH	Alkalinity mg/L	DIC mg/L C	LI	CCPP mg/L	Copper mg/L	Lead mg/L	Buffer Intensity mM/pH	CO_2 mg/L	AI	RI
0.00	0	7.33	20.00	5.38	-1.73	-6.47	0.342	0.322	0.101	2.14	10.11	10.76
0.17	0	7.30	19.86	5.38	-1.76	-6.73	0.371	0.063	0.107	2.26	10.08	10.82
0.33	0	7.28	19.72	5.38	-1.79	-6.99	0.355	0.042	0.113	2.38	10.06	10.85
0.50	0	7.25	19.59	5.38	-1.81	-7.25	0.276	0.034	0.118	2.50	10.02	10.88
0.67	0	7.23	19.45	5.38	-1.84	-7.51	0.232	0.029	0.124	2.62	9.99	10.91
0.83	0	7.21	19.31	5.38	-1.87	-7.77	0.204	0.026	0.129	2.74	9.97	10.94
1.00	0	7.19	19.17	5.38	-1.89	-8.03	0.184	0.023	0.135	2.86	9.94	10.97
1.17	0	7.16	19.03	5.38	-1.91	-8.29	0.170	0.022	0.140	2.98	9.92	10.99
1.33	0	7.14	18.89	5.38	-1.94	-8.55	0.159	0.020	0.146	3.10	9.90	11.02
1.50	0	7.12	18.76	5.38	-1.96	-8.81	0.150	0.019	0.151	3.22	9.87	11.04
1.67	0	7.10	18.62	5.38	-1.98	-9.07	0.143	0.018	0.156	3.34	9.85	11.07
1.83	0	7.09	18.48	5.38	-2.00	-9.33	0.137	0.018	0.161	3.46	9.83	11.10
2.00	0	7.07	18.34	5.38	-2.03	-9.59	0.132	0.017	0.166	3.59	9.81	11.12
2.17	0	7.05	18.20	5.38	-2.05	-9.85	0.128	0.016	0.171	3.71	9.79	11.14
2.33	0	7.03	18.06	5.38	-2.07	-10.11	0.125	0.016	0.176	3.83	9.76	11.17
2.50	0	7.02	17.93	5.38	-2.09	-10.37	0.122	0.016	0.181	3.95	9.74	11.19
2.67	0	7.00	17.79	5.38	-2.11	-10.63	0.120	0.015	0.186	4.07	9.72	11.21
2.83	0	6.98	17.65	5.38	-2.13	-10.89	0.118	0.015	0.190	4.19	9.71	11.24
3.00	0	6.97	17.51	5.38	-2.15	-11.15	0.116	0.015	0.195	4.31	9.69	11.26
3.17	0	6.95	17.37	5.38	-2.16	-11.42	0.115	0.015	0.199	4.43	9.67	11.28
3.33	0	6.94	17.24	5.38	-2.18	-11.68	0.113	0.014	0.204	4.55	9.65	11.30
3.50	0	6.92	17.10	5.38	-2.20	-11.94	0.112	0.014	0.208	4.67	9.63	11.33
3.67	0	6.91	16.96	5.38	-2.22	-12.20	0.112	0.014	0.212	4.80	9.61	11.35
3.83	0	6.89	16.82	5.38	-2.24	-12.46	0.111	0.014	0.217	4.92	9.59	11.37
4.00	0	6.88	16.68	5.38	-2.26	-12.72	0.110	0.014	0.221	5.04	9.58	11.39
4.17	0	6.87	16.54	5.38	-2.27	-12.99	0.110	0.014	0.225	5.16	9.56	11.41
4.33	0	6.85	16.41	5.38	-2.29	-13.25	0.110	0.014	0.229	5.28	9.54	11.43
4.50	0	6.84	16.27	5.38	-2.31	-13.51	0.110	0.014	0.233	5.40	9.52	11.45
4.67	0	6.82	16.13	5.38	-2.32	-13.77	0.110	0.014	0.236	5.52	9.51	11.47
4.83	0	6.81	15.99	5.38	-2.34	-14.03	0.110	0.014	0.240	5.64	9.49	11.49
5.00	0	6.80	15.85	5.38	-2.36	-14.30	0.110	0.014	0.244	5.77	9.47	11.51

Generated Graphs









(757)322-2001 ... 6/14/16

Monitoring of the CCT performance will be conducted in the following locations:

1. Raw and finished (POE) water quality will be measured at least weekly at the treatment facility, including pH, hardness, alkalinity, TDS, temperature, iron, manganese, chloride, sulfate and phosphate.

2. Distribution system water quality will be monitored at the same six hydrant locations as have been previously tested, as well as the Fieldsboro interconnection. Testing will include the same parameters as are tested at the treatment facility and will be conducted according to the following schedule.

    a. Accelerated Passivation Period – weekly
    b. Acclimation / Stabilization Period – bi-weekly
    c. Maintenance Period - monthly

3. Water Quality Parameters (WQP's), including pH, alkalinity and phosphate residual, will be monitored as per current schedule, with bi-weekly samples at the POE, and quarterly samples in thee distribution system (current sites).

4. The City will continue its free sampling program to residents, taking lead samples upon request. These results will be used to track the ultimate performance of the CCT, in advance of future compliance sampling.

The Study is anticipated to continue throughout the 2019.2 and 2020.1 compliance periods, ending June 30, 2020. The final report on the Study findings will be submitted to the NJDEP by August 15, 2020.

Conclusion

The BCWD is proposal to conduct a full-system Corrosion Control Demonstration Study as required by the NJDEP's letter dated July 1, 2019. Based upon existing water quality and treatment constraints, it has been determined that a zinc orthophosphate product (Shannon SLI-5216) would be the optimal inhibitor to add at the treatment facility as a replacement for their current ortho/polyphosphate blend.

The chemical change will be made upon approval of the Study Plan and Temporary Treatment Approval by NJDEP and will continue through June 30, 2020. Treatment performance will be measured at the treatment facility, in the distribution system and in customers' homes as detailed herein. The BCWD believes that this Study will document the effectiveness of the ZOP inhibitor and lead to full compliance with the LAL in future compliance periods.

The BCWD requests that the NJDEP review this Plan at their earliest opportunity, as the optimal time to begin the Study is in late September / early October, when the regularly scheduled flushing program can help accelerate the spread of the inhibitor throughout the distribution system.

Should there be any questions or comments regarding the submittal, please contact the undersigned.

Sincerely,
REMINGTON & VERNICK ENGINEERS

Mark A. Hubal, P.E., BCEE
Water Engineer

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